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TRANSLATION

THE HOT MOLDING OF CERAMIC PRODUCTS

By

P. O. Gribovskiy

FOREIGN TECHNOLOGY DIVISION

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THE HOT MOLDING OF CERAMIC PRODUCTS

BY: P. O. Gribovskiy

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INTRODUCTION

Present day ceramic materials possess such high properties, that they can compete with a series of construction materials, including high alloy steels, chromatic metals and hard alloys. The test of the application of ceramic materials for the production on instruments and machine parts could serve as an example of this. As electro insulation, ceramics surpass almost all organic and inorganic material. Besides that, ceramic components are widely used in chemical machine construction, structural techniques and other areas.

Inexhaustible and numerous sources of inexpensive mineral raw material, necessary for the production of ceramics, and the referred to high properties of modern ceramic materials make favorable prerequisites for the wide development of the production of ceramic articles of the most diverse purpose.

However, until now, the production of ceramic articles was not sufficiently widely developed, the cost of the products high, the technology still highly inadequate, it demanded large volume of hand labor, and did not guarantee a sufficiently high quality of product.

Ceramic production, being one of the most ancient, was developed over a long period of time, only along the line of producting household dishes, structural and fire-proof ceramic. Only during the last century did ceramic articles began to be used more widely in techniques.

The development of native science and techniques brought forth a new demand for ceramics in the direction of increasing the physical and chemical properties, preciseness of measurements and complexity of the configuration of the products.

In connection with this, research work on the creation of new ceramic materials, possessing special properties (high dielectric permeability, with low dielectric losses, high mechanical stability, etc), acquired a wide range.

As a result of the scientific work of Soviet scientist, B.M. Vul, N.P. Bogorodistkii, P.P. Budnikov, I.I. Kityagorodskii, D.N. Poluboyarinov, G.I. Skanav, G.A. Smolenskii and others, science was enriched by a series of discoveries and developments in the field of new ceramic materials.

At that time, in the technology of making products from the new ceramic materials, technological processes were retained, based upon the plastic properties of the ceramic pastes. For the execution of these technological processes, the new ceramic materials should, without fail, possess plastic characteristics; for that purpose, clay materials or other plasticized bonds are usually introduced into their composition.

Since ceramic materials containing clay seemed unable to satisfy the increasing demands for fire-resistancy, for electrical properties, mechanical strength, etc., there emerged the clearly expressed trend to decrease the quantity of clay entering into the composition of the substance, and even to exclude it completely.

However, the exclusion of clay from the composition of the substances leads to a sharp qualitative change in the technological properties of the ceramic composition - a lowering and even a lack in the necessary plastic properties when mixing with water.

The numerous attempts of creating plastic substances, at the expense of introducing different plasticized bonds, carry, as a rule, the character of particular solutions worked out by the authors of the new ceramic material with the view of at least a partial practical application of it.

For a long time, in neither the U.S.S.R. nor abroad, was there serious generalized research and advances in solving the problem of making products from non-plastic materials. The well-known methods of dry and moist compression did not guarantee the possibility of making the products of a high quality, with all the necessary configurations. The technology of making ceramic products also was developed at unsatisfactory speeds.

In the last fifteen years, the author, with collaborators, with the assistance of a great collection of engineers, technicians, and workers for a number of different undertakings, developed a new trend in the field of technology of ceramic products, based on the complex use of the modern achievements in the field of physical chemistry of surface appearance, the technology of ceramics and the technology of metals.

This new trend received the name of the technology of hot molding of ceramic products.

The essence of the technology of hot molding consists in making thermoplastic molding systems from powdered hard metals in a mixture with organic substances, with the subsequent flooding of these systems in a liquid state under increased temperature into the metallic molds. The casting systems cool off in the mold and harden, acquiring the configuration of the working part of the mold. The obtained intermediate product (casting) undergoes roasting in order to receive the finished ceramic product.

The first experiments, conducted in the years of the Great Patriotic War, of casting half-finished ceramic materials did not give positive results. During the flooding of the metallic molds, folds and other defects were formed on the surface of the castings, and in the body of the casting a large number of air bubbles and blisters developed. In order to obtain molding systems, it was necessary to introduce 35-40% paraffin (by weight).

The question arises, how to guarantee good filling of the metallic mold and at the same time to obtain an intermediate ceramic product from which, after roasting, a high-quality product could be obtained.

It seemed necessary to establish what characteristics the casting system and half-finished material (casting) must possess for this, what parameters characterize these properties and by what method it is possible to identify them.

The following are the basic questions, called for by scientific-exploratory workers in the process of forming a technology of hot molding of ceramic products.

1. WORKING OUT THE FUNDAMENTALS OF FORMING MOLDING SYSTEMS

a) Defining the demands made of molding systems.

b) Establishment of parameters, characterizing the property of molding systems, and the development of methods of their identification.

c) The development of compositions and methods of preparing molding systems, possessing the necessary properties for the execution of the process of molding intermediate material and the consequent heat treatment (roasting) of products.

d) Research on the influence of different factors (composition and character of the powder, the composition and characteristics of the organic bond, the technological methods, etc.) on the process of formation and the characteristics of molding systems.

2. WORKING OUT FUNDAMENTALS OF PREPARING (MOLDING) CERAMIC INTERMEDIATE MATERIALS

a) Working out the methods of making molded intermediate materials, of guaranteeing the receipt of roasted products of high quality, of presenting prespectives from the view point of labor productivity and the possibility of mechanization and automation of the processes.

c) Working out the fundamentals of the construction of the molded forms and creating their model structure.

d) Developing the necessary special equipment.

e) Investigation of the nature of the occurances taking place in the formative process of the intermediate materials during hot molding and the influence of the basic factors on the process of casting intermediary materials and characteristics of roasted ceramic products.

3. WORKING OUT FUNDAMENTALS OF HEAT TREATMENT (ROASTING) OF MOLDED CERAMIC PRODUCTS

a) Investigation of the process of removing organic bonds from the molding (intermediary material) during heating and the developing of methods of accomplishing this.

b) Analysis of the influence of basic factors (the properties of the molding systems, the molding, methods, etc.) on the process of heat treatment (roasting) of the molded products and the development of a technology, guaranteeing the receipt of quality finished articles, possessing the necessary properties, the given geometric form and precise dimensions.

The practical development of hot molding technology, begun by working out a method of "gradually-freezing", was carried out by the author in 1946 (L.43).

The application of the "gradually-freezing" method in the period 1946-1948, caused the setting up of a series of investigations, on the basis and in the result of which, in 1948, the process of hot molding under pressure was worked out (L.44).

The method of molding under pressure played a decisive role in the development of hot molding technology, as it guaranteed:

a) high productivity of labor.

b) high precision of the geometrical shape and dimensions.

c) information as to the smallest necessary detail after shaping the product.

d) universality of method, giving the possibility of forming products of different form and dimensions.

e) simplicity of technological proceedings, not demanding a high skill of the worker-operator.

After the development and introduction into production of the process of hot molding under pressure, the new technology quickly began to win a strong place for itself in industry and to develop itself as a new independent branch of ceramic technology.

The technology of hot molding, which is often called "the technology of non-plastic materials", guarantees the possibility of manufacturing products from the so-called non-plastic materials (such as, powders, which do not form plastic systems upon mixing with water).

This condition creates an exceptionally wide area of use of hot molding, since it guarantees the possibility of making products from any hard material, beginning with the natural minerals, pure oxides, carbides, metals, etc., and ending with the multi-component, complex synthetic materials and their combinations,

A similar series of theoretical problems, formally inadequately studied in ceramic technology, were worked out on a level with the decision to undertake an applied course.

At the present time ceramic is broken down into divisions, set up according to the characteristic of the ceramic material's destination; structural ceramics, fire-proof ceramics, electro-ceramics.

In each division, all the problems of ceramics are separately examined and studied, beginning with the ray material, the material obtained, the technology of the articles, etc., and ending with the obtained finished production.

In order to assure the efficient solution of the new problems, arising in the processing of hot molding technology, it seemed expedient to differentiate the whole complex of problems, affected by it, into sections, connected by nature and the specific of the methods of study and technological nature, namely:

1) ceramic material-management
2) technology of ceramic materials
3) technology of ceramic products.

For the most part, at present, they lag behind in developing scientific fundamentals of the division of technology of ceramic materials and articles. For this reason, the basic attention in the present work was paid to theoretical development of these divisions and they are being studied in more detail.

It is necessary to note that in industry there is still an insufficient use of the possibility of the technology of hot molding of ceramic articles, although it is applied in more than 200 enterprises in the USSR and in a number of countries abroad (China, Czechoslovakia, GDR, and others).

In many instances, this explains the absence of sufficient knowledge about the technology from organic literary material in this field.

Until now, the technology of hot molding has come to light only in a series of the author's documents, monographs, and articles (L43-72), coming out in a small edition.

CHAPTER TWO

CASTING SYSTEMS (DROSSING)

2-1 The fundamentals of the technology of preparation and the characteristics of molding systems.

a) Definition and principal of forming molding systems. Molding systems (drosses) applied for carrying out the hold molding process is called the dispersed system, consisting of a powder of hard material (dispersed phase) and of the technological bond (the dispersion medium). The molding system has the ability to fuse with an increase of temperature and to harden upon cooling.

The powder is the basic component of the system, since from it a product is formed later on. The technological bond is the substance temporarily introduced for securing the necessary technological properties of the system. After the completion of its function, the bond is separated from the half-finished product and the ceramic product is formed from the powder left in the half-finished product of resulting design.

Thus, the bond in the system has only technological functions, and therefore is called "technological".

The molding system can be prepared from powders of the most varied hard materials: from natural minerals, from synthetic ceramic materials, glass, metal carbides, and the like.

As technological bonds for the preparation of molding systems, organic thermo-plastic substances are employed (paraffin, pitch, and the like) with the addition of surface active substances .(fatty acids, was, and the like).

The ties of the technological bond (the melting temperature, ductility, polarity, etc.) incorporating the particles of powder into the system, basically predetermine the properties of the resulting system.

The process of preparing the molding system consists of mixing the powder with the bond at the appropriate temperature.

The molding system, being formed as a result of the mixing of the bond, possesses a number of specific characteristics related to its composition, method of preparation, and the properties of the original components (the powder and the bond).

The molding system is formed as a result of the adsorption on the surface of the powder particles of the molecules of the technological bonds.

The molecules of the technological bond form this adsorption layers (drosses) on the surface of the powder particles, separating the particles from each other, and guaranteeing their mutual relative mobility (fluidity of the system at the expense of decreasing internal friction).

The films of the technological bond, coating each particle of powder, are melted down with each other and form the continuous phase of the system - the dispersion medium. The cohesion forces of the technological bond make conditions for the continuity, the coherence of the casting system. If an allowance is made that in the thin adsorption layer (film), the technological bond preserves the volumetrical characteristics inherent in it, then it would be possible to expect that the properties of the molding system (ductility, etc.) will coincide with the characteristics of the bond. However, it is known (L.95) that in the adsorption layer the characteristics of the substance are essentially altered. On the strength of just this one circumstance, the characteristics of the molding systems cannot fully coincide with the characteristics of the technological bond, although they are, to a great degree, related to them. Besides that, the characteristics of the system are related to the characteristics of the dispersed phase (the particules of powder) and the collective interrelation between the dispersion medium and the dispersed phase.

One of the basic technological claims put to the molding system is the maximum degree of filling in the volume of the system with particles of powder, that is the system should have the maximum possible coefficient of baking (packing). With this, the molding of various products.

The degree of filling the capacity of the system with powder particles (K_{up}) in the first place is related to the thickness of the film of the technological bond on the surface of the particles and to the size of the particles, i.e. to the amount the technological bond in the system. If the form of the particles is taken conditionally as spherical, then the relation of the coefficient of packing to the thickness of the film of the bond can be expressed by the relation.

$$K_{up} = \frac{D^3}{(D + 2 \quad)^3} \qquad (2\text{-}1)$$

where D - diameter of the particle, M.C.

- the thickness of the film of bond, M.C.

Thus, for the obtaining a high density in packing the particles in the system, it is necessary to create the thinnest film layers of the bond, at the same time, a mutual mobility of the powder particles. The attainment of such a result is possible with a change of the surface active substances introduced in small amount into the composition of the technological bond.

Theadsorption of the molecules of a surface-active substance on the surface of the powder particles, even in the form of a monomolecular layer, leads to an essential change of the properties of the surface of the particles which in turn, guarantees the possibility of the formation of molding systems, with a decrease amount of bond.

The decrease of the quantity of the technological bond, necessary for forming the molding system is aided also by the creation of optimum conditions (guaranteeing adsorption on the surface of the fresh impression. a choice of temperature condition, etc.) upon mixing the components of the system. The form of the powder particles has a definit value.

Thus, it is possible to consider, as fundamental factors determining the process of formation and the properties of the molding system:

a) The composition and properties of the powder particles;

b) the composition and properties of the technological bond;

c) the collective interrelation of the powders-bonds, i.e., the composition of the system;

d) the conditions of the formation of the systems (temperature conditions, method, and density of the mixture).

The choice of the composition of the powder for obtaining a molding system is determined by the claims put to the properties of the finished ceramic product. Consequently, the basic task is the securing of the possibility of making molded systems from powders of any composition, accounting for their pecularities and properties. As basic parameters of powders having an effect on the formation of casting system, it is possible to consider:

1) adsorption capability of the powder (in relation to is structure and characteristics);

2) the magnitude of the specific overall surface (dispersion and granulometrium);

3) the state (purity) of the surface of the powder particles (the presence of adsorption molecules of water and other substances).

The choice of technological bond is determined by the claims put to the properties of the molding system. The technological bond should possess a definite complex of properties (thermoplastic viscosity and the like) and an adhesion to the surface of the powder particles sufficient for the creation of the molding system.

The adhesion of the bond to the surface of the powder particles should be more than the mutual adhesion between powder particles. If the mutual adhesion between the powder particles is more than their adhesion to the bond, then the particles will stick together (coagulate) and the sliding molding system will not be formed.

CHAPTER FIVE

PRACTICAL VALUE AND AREAS OF APPLICATION OF THE HOT MOLDING TECHNOLOGY

5-1 Several features and possibilities of the technology.

The universality of the hot molding technology apparently should be considered as one of its most remarkable feature. The technology of hot molding guarentees the possibility of making products for practical purposes out of any hard substances: mineral, oxides, carbides, metals, glass, etc..

Along with this the technology of hot molding secures the possibility of making products of the most varied configurations and dimensions.

These two circumstances give the basis for considering the technology of hot molding extreemely effective for the mass production of various products.

The possibility of making different kinds of products out of any hard materials creates real grounds for the development and practical application of new synthetic materials and products from them.

The possibilities of using additional raw materials are widened, where upon the raw material can be used, which ordinarity was seldom employed or generally not used in ceramic technology.

The possibility is created of making products out of materials possessing high operational characteristics (hardness, mechanical durability and the like), causing great difficulties in making products by the usual technological methods (for example, pure oxides, some hard metals, carbides, kermetes, and metallo-ceramics, and others).

Finally, the possibility appears of making products possessing different properties in various elements of volume (polyceramic products). The understanding of polyceramic is new and requires some clearing up. (L. 54)

A polyceramic product is made out of two-three materials, more varied according to composition, by means of continous drenching of the form with drosses of these materials. As a result, there is obtained a semifinished piece (the molding) of the end product, the distinct elements of which are made from the various drosses.

The intermediate product is subjected to a thermal processing, as a result of which, the baking occurs and a polyceramic product is formed, possessing various properties which are necessary to combine into a single component. For example, it is possible to prepare in this way, plates for printed setting of radio-units, electrical condensers with a fixed or variable value TKE, etc.

With this arises the necessity of a rational choice of the materials being combined. The selection of materials (and the molding drosses from them) should be produced along with guaranteeing the necessary combination of electro-physical properties on the basis of observation of the following conditions:

1) the density of the baling of powder particles K_{up} in the molding drosses of the various materials prepared for the manufacturing of a polyceramic product should be the same;

2) at the molding of the product in the junctions of various materials, a reliable fusion of the drosses should be guaranteed, at the expense of choosing suitable technological methods;

3) the materials being combined should have the same baking temperature;

4) the coefficients of the thermal expansion of the materials combined should be close or equal to one another;

5) the chemical reaction of the materials being combined at

baking temperatures should be limited to avoid the formation of a low-melting union and the ruining of the product.

The first experiments (L.54) of receiving poly- and bi-ceramics, with regard to the conditions set forth above, were conducted on a series of materials with the preparation of the specimins in the form of bi-ceramic little tubes and plates (fig. 5-1)

During the conslusion of the tests, material were used, the and properties of which are cited in table 5-1.

As a result of the conducting of tests combining various pairs from the number cited in the table of materials, a number of specimins of bi-ceramic tubes and plates were successfully obtained on the basis of using materials approximating one another in chemical composition (for example, TsK-8 and TsK-10) and with varied chemical composition (for example, SFS-1 and TsB-35) The most reliable results and qualitative bi-ceramic specimins are obtained with the use of materials related according to chemical composition of the materials (TsK-8 and TsK-10 etc). Models of condensers were made from the obtained specimins, guaranteeing the receipt of the fixed TKE (in fig, 5-1, the metallized surfaces are shown by a dotted line).

Preliminary tests give the basis for considering that the reception of polyceramics, on the basis of using the technology of hot molding, is a real and perspective task, but it requires a further and more extensive investigating work on the creation and choosing of materials possessing a complex of the necessary electrophysical properties and applied for combining in polyceramic products.

The possibility, guaranteed by the technology of hot molding, of making products of any configuration for practical purposes, creates the grounds for its use in making a very wide assortment of products and the development of new, perspective constructions.

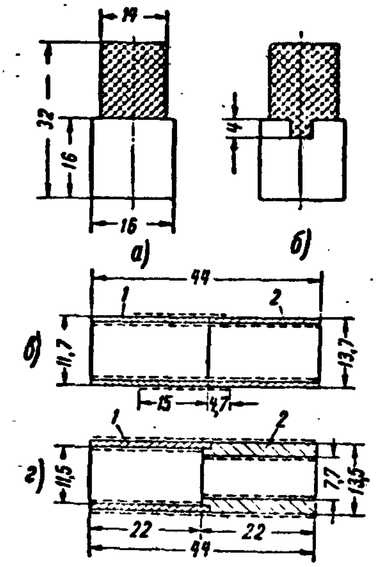

Fig. 5-1. Bi-ceramic specimens (dotted line marks the metallized surface).

a- plate with butt joint;
b- plate with scarf joint;
B- pipe with the junction on the butt;
г - pipe with scarf joint.

In contrast to the majority of methods in using the hot molding technology, the complication of the shapes of the ceramic product usually doesn't cause serious difficulties, decreasing of labor productivity, and the necessity of employing highly qualified workers. The complication of the shape of the products only causes the complication and rising cost of the molded form, which is insignificantly reflected in the net cost of the products.

In connection with this, in the developing of new constructions of the products, the possibility is opened of the most rationalized use of capacity, decreasing of weight and the like, at the expense of some complication of the shape of the product which earlier was presented as unsuitable.

Table 5-1

Index of material	Crystallized base	Temp. of caking °C	Basic properties		
			ε	$tg\delta \cdot 10^4$	$TKE \cdot 10^6$
STs-1	Celsian	1 420-1 450	7.5	2	+50
TsS-24	the same	1 370	7.0	8	+60
TsB-1	Zirconate barium	1 340-1 450	33	3	-530
TsBS-25	the same	1 370	18	5	-67
TsB-35	Celsian and zirconate barium	1 410 1 430	13	4	-100
TsK-1	Zirconate calcium	1 430-1 450	28	8	+20
Sh-1	Spinel	1 320-1 330	6.5	8	+120
T-150	Titanite calcium	1 320	140	3	-1500
T-1	Rutile	1 430-1 450	100	4	-700
TB-1	Titanite barium	1 320-1 330	1500	200	
TsK-8	Zirconate calcium Zirconate barium	1 410-1 430	27	10	+35
TsK-10	the same	1 410-1 430	27	5	-20

Fig. 5-2 Bi-ceramic specimens,

5-2 The areas of application of the technology of hot molding.

The technology of hot molding is successfully applied for the manufacture of products from a large number of different kinds of materials and possessing various properties.

A list of materials applied in the technology of hot molding is cited below:

Name of materials	Symbols, special names, etc.
Clinoenstatite	SK-1, B-17, S-61 and others.
Mullite and mullito-corundum	Electro-porcelain, radio-porcelain, ultraporcelain, zirconic porcelain, ascharite porcelain and others.
Cordierite	CR-15 and others
Fosterite	LF-2 and others
Celsian	BAS-1, BAS-2, ŜTs-1 and others.
Spinel	Ŝh-1 and others.
Corundum	Borcorundum, synoxal-49, T̂sM-332 and others.
Titanite of calcium, magnesium, barium, strontium	TC-20, T-80, T-150, T̂s-70, SM-1, T-40, T-900 and others.
Zirconate of calcium, barium, leas and others.	ZK-15, ZB-4, and others.
From pure oxides	BeO, ZrO_2, ThO_2, Al_2O_3, and others.
Magnetic, permeability	Ferrites
Carbides and semi-conductors	Silicon carbide and others.
Metalloceramics	Hard alloys and others
Glass, and others	No. 69, 74, and others.

On the basis of the use of the enumerated assortment of materials, hot molding was applied for the manufacture of:

1) electro-insulated products;
2) electric condensers;
3) piezoceramic products;
4) magnetic and magnetic permeable ceramics (ferrites)
5) fireproof and thermal resistant products;
6) mechanical components and instruments;

7) chemically stable products;
8) metalloceramic products;
9) artistic and every-day household products.

The possibility of manufacturing high-quality products of complex design, with a sufficiently high precision of dimension, effected the development of new and more efficient designs of high frequency installation components.

Let's pause briefly on the description of the examples of some solutions in this direction.

With the view of increasing the quality and decreasing the weight and size of radio-equipment, operations were conducted (L-54) on the creation of small-sized trimmer condensers, of high stability coils, of inductances with interior coil, and also the creation of ceramic bases for printed assembly.

The specimens of some of these units and components are cited in fig. 5-3.

All the cited ceramic units and components are designed . calculating on the possibilities of the technology of hot molding under pressure.

A special feature of the design of small sized ceramic filters is the fact that the functions of several components are concentrated in one configurationally complex ceramic component (basis of the filter). Thus, for example, caps appear simultaneously as condensers and screens etc., (fig. 5-3 a).

A special feature of the application of hot molding for a printed setting is the fact that the obtaining of a ceramic plate with the complex feature of current-conducting lines is accomplished by the molding of such a plate with a contour projection or depressions, being subjected to metallization. by means of a rolling drum smeared with silver, which doesn't bring about technological difficulties. The simplest molded forms, for such plates, can be manufactured by the method of etching of copper or steel plates.

Some interest is offered by the operation (L. 65) in creating an inductivity coil with an inner threat on which a current-conducting layer is built up. As was shown by tests, the temperature coefficient of inductivity with such a coil of this sort, decreases. The technology of manufacturing is extremely uncomplicated, since the building up of the turns (current-conducting layer) is accomplished by a simple flat roller (cylinder).

Photographs are cited, in fig. 5-4, of some varities of electro-insulated high-frequency components, manufactured by means of hot molding under pressure of various materials.

The employment of the technology of hot molding for the manufacture of electric ceramic condensers guarantees the possibility of the use of the highest quality condenser materials and the creation of new original designs of condensers with better parameters.

The most graphic example of this can be served by the development of the small sized condensers KLG (being put out by the industry under the index KLS), the more detailed description of which will be shown below.

In figure 5-5, condensers are cited, manufactured from various materials by means of hot molding under pressure.

Piezoceramics is a completely perspective and relatively new field of application of the technology of hot molding. Here, as in a number of other fields, the wide possibilities of the

Fig. 5-3. Specimens of ceramic radio-components and units.

a) electric filter; b) trimmer (condenser).

technology of hot molding led to the creation of new original designs of piezo-ceramic products. It is possible to refer the development of all-ceramic electric filters to the number of examples deserving special attention. (L. 72) a brief description of this is also given below.

Fig. 5-4. A photograph of electro-insulated components from various ceramic materials.

Fig. 5-5. Ceramic condensers, manufactured by molding under pressure.

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Fig. 5-6. Ferrite components manufactured by molding under pressure.

The application of the technology of hot molding for the manufacturing of magnetic and magneto-permeating ceramics (ferrites), guaranteeing the possibility of the effective preparation of a num- of products of a complex configuration and various dimensions, is illustrated in fig. 5-6 in which some details are cited.

The application of the technology of hot molding has an extra great value in the field of high fireproofed and thermal-resistant products made from pure oxides and used in various special arrangements and, in particular, in the field of atomic techniques.

The preparation of products from pure oxides with hot molding under pressure secures the possibility of preserving the purity and high properties of the initial materials and the possibility of obtaining from them the products, which, as a result of the complexity of the configuration, is not possible to prepare by any other means.

In fig. 5-7, are cited some of the simplest products, made from pure alluminum oxide, berrylium oxide, thorium oxide and others.

A completely independent meaning is acquired by such a wide field of application of the technology of hot molding as machine-constructing ceramics. Even the relatively little experience of of the application of ceramics as machine components, the cutting and measuring of instruments, demonstrated an exceptional perspective of this new field of techniques (L. 109, 151).

The application of the technology of hot molding is also extremely effective for manufacturing chemically stable products for various destinations. A massive production was begun of artistic and everyday-domestic ceramic products (Fig. 5-8) by the enterprises of the Kiev Council of National Economy (1).

Even a brief description of the practical examples of the

Fig. 5-7. Products from pure metal oxides

application of the technology of hot molding in all the enumerated fields of technique cannot be packed into the framework and space of the present monograph and should appear as a subject of special, individual reports for each field of application.

Nevertheless, it is suitable to make a description of the separate and most graphic examples, showing how great are the possibilities opened to the technology of hot molding in the business of creating new product designs.

Fig. 5-8. Domestic and artistic ceramics, manufactured by means of hot molding under pressure.

5-4 The effectiveness of the technology of hot molding under pressure and the perspectives of its development.

The existing, generally known technological system of manufacturing ceramic products has a number of specific deficiencies: the great duration of the technological cycle process; the low mechanical stability of the semifinished product; large manufacturing flaws as a result of deformation and crackings during drying and roasting; low precision of the products; insufficient stability of properties of the products, etc.

Hot molding under pressure of ceramic products guarantees almost the complete correction of the defects indicated above. The technological cycles process is sharply abbreviated (by several times the number). The mechanical stability of the semifinished product increases three or four times which decreases the flaws in impression and breakdown during transportation and preserving of the semifinished product.

Flaws, because of cracks and deformation, are reduced to a minimum as a result of the creation of a semifinished product of an efficient structure.

The exact numericaldata of the economic effect from the application of the method of hot molding, regardless of its extreme economy and obvious effectiveness makes itself extremely difficult to produce, since the method received the greatest application for the manufacture of high quality, --- precise and complex ceramic products which, according to the usual existing ceramic technology, either generally can't be made or the labor capacity and cost in manufacturing the product and the flaws in production are exceptionally great.

In connection with this, only a listing of the properties is cited below, characterizing the effectiveness of the method of molding under pressure:

1. The labor productivity, in the molding of the products by means of molding under pressure on simple apparatuses, is 2-3 times higher by comparison with one of the most perfected methods of the existing technology-compression. When operating on automatic machines for molding under pressure the labor productivity is still greater since along with the high productivity of the automatic machine one worker can work several machines. Productivity on simple apparatuses forms up to 2,500 units per shift, and on an automatic machine amounts to 50,000 units per shift.

2. The obtaining of ceramic products with a high precision of measurements (IV-V classes of precision) is guaranteed, which in the majority of cases excludes the possibility in the toughness capacity operation of polishing the products after roasting, and, consequently, decreases the hardness capacity, decreases the expenditure of energy and does not require the setting up and use of a fleet of polishing mills.

3. The acquiring of products of finished design is secured depending on its complexity. This makes for a great saving in labor and overhead expenses since the necessity falls away in the operations of the mechanical completion of the product and in the corresponding fleet of mills.

4. The molds (equipment) for the realization of the method of molding under pressure is significantly simpler in design and is 4-5 times cheaper in manufacturing than the press-molds for compression. Along with this, the wear-and-tear stability of the molds for hot molding under pressure is 10-15 times higher than the press-molds for compression. This makes conditions for greater saving in the expenditures for the manufacture, repair and operation of the molds.

5. The expense of the material going into the manufacture of the product is minimal, since, with the application of molding under pressure, there are practically no discrepencies as a consequence of the fact that no kind of allowances are required for the subsequent processing of the semifinished product. Insignificant scraps of material, resulting with the removal of the runner, are immediately used for the molding of other components without any additional processing.

6. For the manufacture of even the most complex components, a highly qualified working force is not required, which lowers the net cost of production.

7. The simplicity of design, the cheapness and small size of the equipment employed in combination with its high productivity guarantee the decrease of demands in the manufacturing areas, and the decrease of significant expenses in the operation of the equipment in comparison with the equipment employed in the usual technology (hydraulic presses and the like).

8. The technology of hot molding not only guarantees the possibility of manufacturing complex products from high quality non-plastic materials, but along with this it leads to a number of additional positive moments.

Thus, for example, the semifinished product and the initial dross can be preserved for an unlimited continuous time (There is no drying as in the usual technology).

This feature of dross and the semifinished product open up completely new perspectives for the development of the ceramic industry similar to the technology of metals since the possibility is created of separate preparation of a varied assortment of initial materials (molding pigs, round bar material, sheet, etc.) in the semifinished product in separate specialized factories (of the metallurgic type) with the subsequent transportation and use of them for the manufacture of ceramic products of varying properties and configurations at factories manufacturing ceramic products or consuming them.

There is no doubt that such specializing of factories in the ceramic industry creates the possibility of fast progress and a wide introduction into the technique of cheap ceramic products from non-plastic raw materials instead of high-costing plastics and, in a number of cases, even instead of metal products.

9. The effect from the application of the technology of hot molding is summed up in the fact that it guarantees the possibility of the output of such ceramic products which cannot be manufactured by the usual ceramic technology. In the first place, to ceramic products of this kind are related products being employed in the newest radio-technological apparatuses, in special devices and the like.

The experience of operating many enterprises employing the technology of hot molding confirms what has been said. Thus, for example, in one of the enterprises of Chelyabinskii SNKh the transfer over to hot molding from compression and stretching allowed for an increase of the production output by 3 times the amount from a square meter of the manufacturing area and permitted a rise of labor productivity by twice the number, and also cut down the expense of materials by twice the number.

In the factory named after Kozitskii, where, by use of the technology of hot molding, products of 282 names are put out, the yearly economy comprises 300,000 standard hours. At another factory

(Moscow), where almost 300 pattern size molded ceramic components are put out, the cost of the press-molds decreased 3-4 times with the transfer over to hot molding, and their weight was decreased 7-10 times.

At the Baranovskii poreclain factory where they put out open-work plates and other products by the use of the technology of hot molding in a number up to 200,000 units a year, the yearly saving comprised 100,000 rubles (at the value in 1960), whereupon the productivity of mold formation increased by 10 times the number in comparison with molding into gypeous molds.

The number of such examples can be substanially increased since at the present time the technology of hot molding on various scales has been employed in 150-200 factories.

In conclusion it is necessary to note that the contemporary level of the technology of hot molding is a result of just a few years of work and, undoubtedly, can be earnestly increased.

Sufficiently great results can be expected from the wide application of the available solutions for simplification of the technology, for example the method of manufacturing molded ceramic products with momentaneous roasting, i.e. without the preliminary removal of the bond in the fill-in, automatic machines for molding, semiautomatic furnaces for the roasting of the molded products, etc.

Along with this the chief possibility of a substanial increase of the properties of the ceramic materials with the use of the technology of hot molding, guarantees the perspective of a broadening of the field of application of ceramic products in connection with an increase of their properties and precision of dimensions along with a decrease in the cost of manufacturing. The real possibility of full mechanization and automation of the process of production with the use of the technology of hot molding under pressure promises a still greater substantial decrease of the net cost and an increase of the quality of ceramic products of the most varied destination. There is no doubt that the development of the operations in perfecting the technology of hot molding and its automation will guarantee within the next few years the creation of automatic lines and, after that, automatic factories for the production of ceramic products.

FOOTNOTE

[1]Miten, N.G., Zubatov, I.N., Romanovskaya, Z.Z., Kurinina, T.I., Vishnevsky, B.I.. The manufacture of porcelain products, by means of hot molding under pressure, "Glass and Ceramics", 1960, No. 9, PP. 38-41.

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